

KEITHLEY

Model 7710 Multiplexer Card

User's Guide

PA-847 Rev. A / 9-02

A GREATER MEASURE OF CONFIDENCE

WARRANTY

Keithley Instruments, Inc. warrants this product to be free from defects in material and workmanship for a period of 1 year from date of shipment.

Keithley Instruments, Inc. warrants the following items for 90 days from the date of shipment: probes, cables, rechargeable batteries, diskettes, and documentation.

During the warranty period, we will, at our option, either repair or replace any product that proves to be defective.

To exercise this warranty, write or call your local Keithley representative, or contact Keithley headquarters in Cleveland, Ohio. You will be given prompt assistance and return instructions. Send the product, transportation prepaid, to the indicated service facility. Repairs will be made and the product returned, transportation prepaid. Repaired or replaced products are warranted for the balance of the original warranty period, or at least 90 days.

LIMITATION OF WARRANTY

This warranty does not apply to defects resulting from product modification without Keithley's express written consent, or misuse of any product or part. This warranty also does not apply to fuses, software, non-rechargeable batteries, damage from battery leakage, or problems arising from normal wear or failure to follow instructions.

THIS WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR USE. THE REMEDIES PROVIDED HEREIN ARE BUYER'S SOLE AND EXCLUSIVE REMEDIES.

NEITHER KEITHLEY INSTRUMENTS, INC. NOR ANY OF ITS EMPLOYEES SHALL BE LIABLE FOR ANY DIRECT, INDIRECT, SPECIAL, INCIDENTAL OR CONSEQUENTIAL DAMAGES ARISING OUT OF THE USE OF ITS INSTRUMENTS AND SOFTWARE EVEN IF KEITHLEY INSTRUMENTS, INC., HAS BEEN ADVISED IN ADVANCE OF THE POSSIBILITY OF SUCH DAMAGES. SUCH EXCLUDED DAMAGES SHALL INCLUDE, BUT ARE NOT LIMITED TO: COSTS OF REMOVAL AND INSTALLATION, LOSSES SUSTAINED AS THE RESULT OF INJURY TO ANY PERSON, OR DAMAGE TO PROPERTY.



Keithley Instruments, Inc. 28775 Aurora Road • Cleveland, Ohio 44139 • 440-248-0400 • Fax: 440-248-6168
1-888-KEITHLEY (534-8453) • www.keithley.com

Sales Offices: BELGIUM: Bergensesteenweg 709 • B-1600 Sint-Pieters-Leeuw • 02-363 00 40 • Fax: 02/363 00 64
CHINA: Yuan Chen Xin Building, Room 705 • 12 Yumin Road, Dewai, Madian • Beijing 100029 • 8610-8225-1886 • Fax: 8610-8225-1892
FINLAND: Tietäjäsentie 2 • 02130 Espoo • Phone: 09-54 75 08 10 • Fax: 09-25 10 51 00
FRANCE: 3, allée des Garays • 91127 Palaiseau Cédex • 01-64 53 20 20 • Fax: 01-60 11 77 26
GERMANY: Landsberger Strasse 65 • 82110 Germering • 089/84 93 07-40 • Fax: 089/84 93 07-34
GREAT BRITAIN: Unit 2 Commerce Park, Brunel Road • Theale • Berkshire RG7 4AB • 0118 929 7500 • Fax: 0118 929 7519
INDIA: 1/5 Eagles Street • Langford Town • Bangalore 560 025, INDIA • 080 212 8027 • Fax : 080 212 8005
ITALY: Viale San Gimignano, 38 • 20146 Milano • 02-48 39 16 01 • Fax: 02-48 30 22 74
JAPAN: New Pier Takeshiba North Tower 13F • 11-1, Kaigan 1-chome • Minato-ku, Tokyo 105-0022 • 81-3-5733-7555 • Fax: 81-3-5733-7556
KOREA: 2FL., URI Building • 2-14 Yangjae-Dong • Seocho-Gu, Seoul 137-888 • 82-2-574-7778 • Fax: 82-2-574-7838
NETHERLANDS: Postbus 559 • 4200 AN Gorinchem • 0183-635333 • Fax: 0183-630821
SWEDEN: c/o Regus Business Centre • Frosundaviks Allé 15, 4tr • 169 70 Solna • 08-509 04 679 • Fax: 08-655 26 10
TAIWAN: 13F-3. No. 6, Lane 99 Pu-Ding Road • Hsinchu, Taiwan, R.O.C. • 886-3-572-9077 • Fax: 886-3-572-9031

The following safety precautions should be observed before using this product and any associated instrumentation. Although some instruments and accessories would normally be used with non-hazardous voltages, there are situations where hazardous conditions may be present.

This product is intended for use by qualified personnel who recognize shock hazards and are familiar with the safety precautions required to avoid possible injury. Read and follow all installation, operation, and maintenance information carefully before using the product. Refer to the manual for complete product specifications.

If the product is used in a manner not specified, the protection provided by the product may be impaired.

The types of product users are:

Responsible body is the individual or group responsible for the use and maintenance of equipment, for ensuring that the equipment is operated within its specifications and operating limits, and for ensuring that operators are adequately trained.

Operators use the product for its intended function. They must be trained in electrical safety procedures and proper use of the instrument. They must be protected from electric shock and contact with hazardous live circuits.

Maintenance personnel perform routine procedures on the product to keep it operating properly, for example, setting the line voltage or replacing consumable materials. Maintenance procedures are described in the manual. The procedures explicitly state if the operator may perform them. Otherwise, they should be performed only by service personnel.

Service personnel are trained to work on live circuits, and perform safe installations and repairs of products. Only properly trained service personnel may perform installation and service procedures.

Keithley products are designed for use with electrical signals that are rated Installation Category I and Installation Category II, as described in the International Electrotechnical Commission (IEC) Standard IEC 60664. Most measurement, control, and data I/O signals are Installation Category I and must not be directly connected to mains voltage or to voltage sources with high transient over-voltages. Installation Category II connections require protection for high transient over-voltages often associated with local AC mains connections. Assume all measurement, control, and data I/O connections are for connection to Category I sources unless otherwise marked or described in the Manual.

Exercise extreme caution when a shock hazard is present. Lethal voltage may be present on cable connector jacks or test fixtures. The American National Standards Institute (ANSI) states that a shock hazard exists when voltage levels greater than 30V RMS, 42.4V peak, or 60VDC are present. **A good safety practice is to expect that hazardous voltage is present in any unknown circuit before measuring.**

Operators of this product must be protected from electric shock at all times. The responsible body must ensure that operators are prevented access and/or insulated from every connection point. In some cases, connections must be exposed to potential human contact. Product operators in these circumstances must be trained to protect themselves from the risk of electric shock. If the circuit is capable of operating at or above 1000 volts, **no conductive part of the circuit may be exposed.**

Do not connect switching cards directly to unlimited power circuits. They are intended to be used with impedance limited sources. NEVER connect switching cards directly to AC mains. When connecting sources to switching cards, install protective devices to limit fault current and voltage to the card.

Before operating an instrument, make sure the line cord is connected to a properly grounded power receptacle. Inspect the connecting cables, test leads, and jumpers for possible wear, cracks, or breaks before each use.

When installing equipment where access to the main power cord is restricted, such as rack mounting, a separate main input power disconnect device must be provided, in close proximity to the equipment and within easy reach of the operator.

For maximum safety, do not touch the product, test cables, or any other instruments while power is applied to the circuit under test. ALWAYS remove power from the entire test system and discharge any capacitors before: connecting or disconnecting cables or jumpers, installing or removing switching cards, or making internal changes, such as installing or removing jumpers.

Do not touch any object that could provide a current path to the common side of the circuit under test or power line (earth) ground. Always make measurements with dry hands while standing on a dry, insulated surface capable of withstanding the voltage being measured.



The instrument and accessories must be used in accordance with its specifications and operating instructions or the safety of the equipment may be impaired.


Do not exceed the maximum signal levels of the instruments and accessories, as defined in the specifications and operating information, and as shown on the instrument or test fixture panels, or switching card.


When fuses are used in a product, replace with same type and rating for continued protection against fire hazard.

Chassis connections must only be used as shield connections for measuring circuits, NOT as safety earth ground connections.

If you are using a test fixture, keep the lid closed while power is applied to the device under test. Safe operation requires the use of a lid interlock.

If  or  is present, connect it to safety earth ground using the wire recommended in the user documentation.

The  symbol on an instrument indicates that the user should refer to the operating instructions located in the manual.

The  symbol on an instrument shows that it can source or measure 1000 volts or more, including the combined effect of normal and common mode voltages. Use standard safety precautions to avoid personal contact with these voltages.

The **WARNING** heading in a manual explains dangers that might result in personal injury or death. Always read the associated information very carefully before performing the indicated procedure.

The **CAUTION** heading in a manual explains hazards that could damage the instrument. Such damage may invalidate the warranty.

Instrumentation and accessories shall not be connected to humans.

Before performing any maintenance, disconnect the line cord and all test cables.

To maintain protection from electric shock and fire, replacement components in mains circuits, including the power transformer, test leads, and input jacks, must be purchased from Keithley Instruments. Standard fuses, with applicable national safety approvals, may be used if the rating and type are the same. Other components that are not safety related may be purchased from other suppliers as long as they are equivalent to the original component. (Note that selected parts should be purchased only through Keithley Instruments to maintain accuracy and functionality of the product.) If you are unsure about the applicability of a replacement component, call a Keithley Instruments office for information.

To clean an instrument, use a damp cloth or mild, water based cleaner. Clean the exterior of the instrument only. Do not apply cleaner directly to the instrument or allow liquids to enter or spill on the instrument. Products that consist of a circuit board with no case or chassis (e.g., data acquisition board for installation into a computer) should never require cleaning if handled according to instructions. If the board becomes contaminated and operation is affected, the board should be returned to the factory for proper cleaning/servicing.

Introduction

NOTE *The Model 7710 will operate properly when installed in one of the following Model 27xx instruments:*

Model 2700 – Equipped with B05 (or later) firmware

Model 2701 – Equipped with A01 (or later) firmware

Model 2750 – Equipped with A04 (or later) firmware

The Model 7710 is a 20-channel differential multiplexer card with the following features:

- Fast actuating, long life solid state relays.
- DC and AC voltage measurement.
- 2-wire or 4-wire measurements (automatically pairs relays for four wire measurements — $n + 10$).
- Temperature applications (RTD, thermistor, thermocouple).
- Built-in cold junction reference for TC temperature.
- Plug-in screw terminal connections.

Topics

Operating instructions.....	page 2
Card configuration	page 2
Fast scanning	page 4
Fast scan using 7710 module with Model 2701 mainframe.....	page 4
Operating considerations.....	page 10
Low-ohms measurements	page 10
Voltage measurements	page 11
Insertion loss	page 12
Crosstalk	page 12
Additional errors for 27xx switch systems.....	page 12
Heat sink temperature measurements.....	page 13
Card handling precautions.....	page 13
Card connections.....	page 14
Wiring procedure	page 15
Typical connections.....	page 17
Connection log.....	page 19
Calibration.....	page 21
Specifications	end of User's Guide

Operating instructions

CAUTION Before installing or removing a Model 77xx plug-in module, make sure the Model 27xx power is turned off and disconnected from line power. Failure to comply may result in incorrect operation and loss of Model 77xx EPROM data.

Switching card operation is covered in the Model 27xx User's Manual. The Model 7710 operates the same as the Model 7700 switching card with the following differences:

- The Model 7710 has no amps channel. The Model 7700 has two amps channels.
- The Model 7710 uses solid state opto-coupled FET relays. The Model 7700 uses latching electromechanical relays. Solid state relays provide longer relay life and are up to six times faster than the electromechanical types used in other switching modules.

WARNING The system's maximum voltage, including other switch modules and front panel terminals, is limited to 60V peak-to-peak AC or DC between any terminal and chassis, or any two terminals when the 7710 is installed. Exceeding these levels creates a shock hazard and could cause damage to the card. Complete specifications are located at the end of this User's Guide.

WARNING When a Model 7710 module is inserted into a Model 27xx, it is connected to the front and rear inputs, as well as the other cards in the system, through the instrument backplane. To prevent damaging the 7710 module or creating a shock hazard, the entire test system and all of its inputs should be de-rated to 60V DC (42V rms).

Card configuration

Figure 1 shows a simplified schematic diagram of the Model 7710 module. As shown, the Model 7710 has channels that are grouped into two banks of ten channels (twenty channels total). Backplane isolation is provided for each bank. Each bank includes separate cold junction reference points. The first bank contains channels 1 through 10, while the second bank contains channels 11 through 20. Each channel of the 20-channel multiplexer card is wired with separate inputs for HI/LO providing fully isolated inputs.

Connections to DMM functions are provided through the card backplane connector.

Channels 21, 22, and 23 are configured automatically by the Model 27xx when using system channel operation. However, by using multiple channel operation (refer to Section 2 of the Model 27xx User's Manual), they can be manually configured.

For example, assume a 7710 module is installed in slot 1 of the mainframe and an external source is connected to Card Source input. To connect the source to channel 11 only, multiple channel operation must be used:

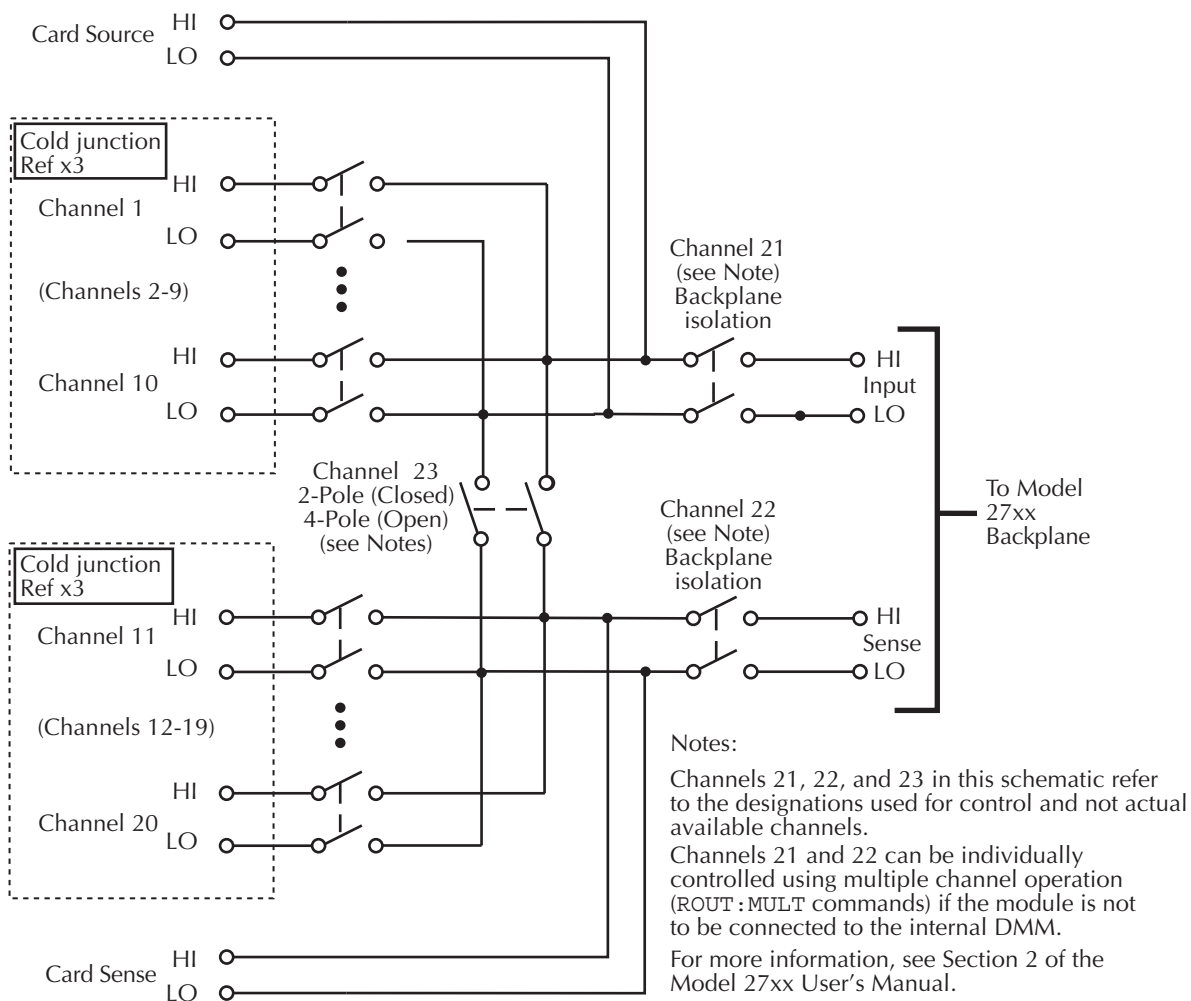
ROUT:OPEN:ALL	' Open all channels.
ROUT:MULT:CLOS (@11,123)	' Close channels 11 and 23.

For the above command sequence, the Digital Multimeter (DMM) of the Model 27xx will be electrically isolated from the test circuit.

When using system channel operation for 4-wire measurements (including 4-wire ohms, RTD temperature, Ratio, and Channel Average), the channels are paired as follows:

CH1 and CH11	CH6 and CH16
CH2 and CH12	CH7 and CH17
CH3 and CH13	CH8 and CH18
CH4 and CH14	CH9 and CH19
CH5 and CH15	CH10 and CH20

Figure 1
Simplified schematic of Model 7710



Fast scanning

Fast scanning is achieved by using the 7710 module (which has high-speed solid state FET relays) with the Model 2701 mainframe. With mainframe speed settings optimized for DCV or ohms measurements, the Model 2701 can scan approximately twice as fast as the Models 2700 and 2750.

To achieve the fastest scan possible, use the following Model 27xx mainframe settings for the scan:

VOLT: AVER: STAT OFF	' Disables filtering.
VOLT: DIG 4	' Sets display resolution to 4.5 digits.
VOLT: NPLC X	' Sets reading rate: ' where: X = 0.01 (2700 and 2750). ' X = 0.002 (2701)
SYST: AZER: STAT OFF	' Disables auto-zero.
SYST: LSYN OFF	' Disables line synchronization.
TRIG: DEL 0	' Sets trigger delay to 0 seconds.
FORM: DATA ASCII	' Formats data as an ASCII string (N/A for 2701).
FORM: ELEM READ	' Returns each reading with units only.
CALC3: OUTP OFF	' Disables limit outputs.
CALC3: LIM1: STAT OFF	' Disables limit 1 test.
DISP: ENAB OFF	' Turns off display.

When finished with the scan, the display can be turned back on with the following command:

DISP: ENAB ON	' Turns on display.
---------------	---------------------

Fast scan using 7710 module with Model 2701 mainframe

The following Visual Basic (VB) Version 6 program demonstrates using the Model 7710 card and Model 2701 mainframe to achieve fast scanning. It makes use of WinSocket control to communicate with the Model 7701 mainframe. This User's Guide is provided as a PDF file on the product information CD-ROM. From Acrobat Reader, the program code can be copied and pasted into Visual Basic.

```

' 7710 DCV FAST SCAN EXAMPLE FOR THE 2701 MODULE
'
' This program is an example of configuring a simple DCV scan on the 7710 with a 2701 mainframe.
' This program acquires readings at a rate of 500/ sec.
'
' Note that a Winsocket control in Visual Basic is being used to communicate with the 2701.
'
'
Const ScanList = "@101:120"

Dim TestRunning As Boolean
Dim DataReceived As Boolean
Dim DataSent As Boolean
Dim Data As String

' A Visual Basic function call when a Form (program window) is opened.
Private Sub Form_Load()
    TestRunning = False
End Sub

' These two functions exit the program and closes the winsocket.
Private Sub ExitButton_Click()
    Unload Me
End Sub
Private Sub Form_Unload(Cancel As Integer)
    Cancel = MsgBox("Exit?", 20, "Exit Verify")
    If Cancel = vbYes Then
        Cancel = 0
        CloseWinsocket
    End If
End Sub

' This function opens the Winsocket for communication with the 2701 ethernet mainframe.
Function ConnectTo2701() As Integer
    Dim Time0 As Single

```

```

If txtAddress.Text = "" Then
    ConnectTo2701 = False
    Exit Function
End If

With Winsock1
    .Protocol = sckTCPProtocol
    .RemoteHost = txtAddress.Text
    .RemotePort = 1394
    .Connect
End With

' Check for proper connection.
Time0 = Timer
While Timer - Time0 < 10! And Winsock1.State <> sckConnected: DoEvents: Wend
    If Winsock1.State <> sckConnected Then
        ' Could not connect to 2701.
        MsgBox "Cannot connect to " + LastAddress + "!", 48, "IP Connect Error"
        ConnectTo2701 = False
        Exit Function
    End If

    ' Connection to 2701 found.
    ConnectTo2701 = True

End Function

' Event to capture data from mainframe.
Private Sub Winsock1_DataArrival(ByVal bytesTotal As Long)
    Winsock1.GetData Data, vbString, 50000
    'Chr$(10) Or
    If (Right$(Data, 1) = Chr$(10)) Then
        Data = Left$(Data, Len(Data) - 1)
        DataReceived = True
    End If
End Sub

' QueryKI() retrieves data from the 2701 over the ethernet connection.
Function QueryKI() As String
    ' Read Ethernet data.

```

```

DataReceived = False
Do
    ' Remain in loop until mainframe is finished sending data.
    DoEvents

Loop Until DataReceived

QueryKI = Data ' Return reading
End Function

' This event occurs when host computer is finished sending data .
' This event occurs when host computer is finished sending data .
Private Sub Winsock1_SendComplete()
    DataSent = True
End Sub

' SendKI() sends data to the 2701 over the ethernet connection.
' SendKI() sends data to the 2701 over the ethernet connection.
Sub SendKI(Cmd As String)
    ' Send command to mainframe and wait for data sent event.
    DataSent = False
    Winsock1.SendData Cmd + Chr$(13)

    Do
        DoEvents
    Loop Until DataSent
End Sub

' Close the winsocket if it is still opened.
' Close the winsocket if it is still opened.
Private Sub CloseWinsocket()
    If Winsock1.State <> sckClosed Then Winsock1.Close
End Sub

' This function is called when the run button is pressed on the Form.
' This function is called when the run button is pressed on the Form.
Private Sub RunTestButton_Click()
    ' If a scan is not already running, begin a new scan.

```

```

    If Not (TestRunning) Then
        Call ScanDCV
    End If
End Sub

```

```

' Data is formatted to show one reading per line in reading window.

```

```

Private Sub Format_Readings(Resp As String)

```

```

    Dim Out_str As String
    Dim Ch As String
    Dim i As Long

```

```

    i = Len(Resp)
    Out_str = ""

```

```

    i = 1
    While (i <= Len(Resp))
        Ch = Mid(Resp, i, 1)
        If (Ch = ",") Then
            Ch = vbCrLf
        End If
        Out_str = Out_str + Ch
        i = i + 1
    Wend

```

```

    Text1.Text = Out_str
End Sub

```

```


```

```

' This is the main function for the 7710 test program.

```

```

Private Sub ScanDCV()

```

```

    Dim NumReadings As Integer
    Dim Resp As String
    Dim Cmd As String

```

```

    If Not (ConnectTo2701) Then ' Open connection to 2701.
        Exit Sub
    End If

```

```

    TestRunning = True

```

```

NumReadings = 1024          ' Take 1024 readings.
Resp = Space$(80)
Cmd = Space$(80)

' Configure the instrument for scanning DCV.
'
SendKI ("*RST")             ' Put instrument in known state.
SendKI ("FORM:DATA ASCII") ' Format data as an ASCII string.
SendKI ("FORM:ELEM READ")  ' Return the reading with units only.
SendKI ("SAMP:COUN " + CStr(NumReadings)) ' Take 1024 readings.
SendKI ("FUNC 'VOLT:DC', " + ScanList)    ' Set function to DCV.
SendKI ("VOLT:RANG 100," + ScanList)      ' Set Range to 100V.
SendKI ("VOLT:AVER:STAT OFF," + ScanList)
SendKI ("VOLT:DIG 4," + ScanList)         ' Read to 4 significant digits.
SendKI ("VOLT:NPLC 0.002," + ScanList)    ' Set NPLC to 0.002.
SendKI ("CALC3:OUTP OFF")                 ' Turn off limit test.
SendKI ("SYST:LSYN OFF")                  ' Turn off line-sync.
SendKI ("DISP:ENAB OFF")                 ' Turn off display.
SendKI ("SYST:AZER:STAT OFF")            ' Turn off auto-zero.
SendKI ("CALC3:LIM1:STAT OFF," + ScanList) ' Turn off limits.
SendKI ("TRIG:DEL 0")                    ' Set trigger delay to 0 seconds.
SendKI ("TRAC:CLE")                       ' Clear reading buffer.
SendKI ("ROUT:SCAN " + ScanList)         ' Set scan list.
SendKI ("ROUT:SCAN:LSEL INT")            ' Initiate scan.
SendKI ("*OPC?")                          ' Determines if mainframe is ready.
Resp = QueryKI()

SendKI ("INIT")                       ' Initiate scan and store in buffer.
SendKI ("*OPC?")
Resp = QueryKI()                        ' Wait for scan to complete.

SendKI ("ROUT:SCAN:LSEL NONE;*OPC?")    ' Stop scan.
Resp = QueryKI()

SendKI ("TRACE:DATA?")                  ' Get readings from buffer.
Resp = QueryKI()
Format_Readings (Resp)

SendKI ("DISP:ENAB ON")                 ' Turn display back on.

CloseWinsocket                          ' Disconnect connection to mainframe.
TestRunning = False
End Sub

```

Operating considerations

Low-ohms measurements

For resistances in the normal range ($>100\Omega$), the 2-wire method ($\Omega 2$) is typically used for ohms measurements. For low-ohms ($\leq 100\Omega$), the signal path resistance in series with the DUT could be high enough to adversely affect the measurement. Therefore, the 4-wire method ($\Omega 4$) should be used for low-ohms measurements. The following discussion explains the limitations of the 2-wire method, and the advantages of the 4-wire method.

2-wire method

Resistance measurements in the normal range ($>100\Omega$) are generally made using the 2-wire method ($\Omega 2$ function). The test current is forced through the test leads and the resistance being measured (R_S). The meter then measures the voltage across the resistance value accordingly.

The main problem with the 2-wire method, as applied to low-resistance measurements is the test lead resistance (R_{LEAD}) and the channel resistance (R_{CH}). The sum of these resistances typically lies in the range of 1.5 to 2.5 Ω . Therefore, it is very difficult to obtain accurate 2-wire ohms measurements below 100 Ω .

Due to this limitation, the 4-wire method should be used for resistance measurements $\leq 100\Omega$. This method is explained as follows:

4-wire method

The 4-wire (Kelvin) connection method using the $\Omega 4$ function, as shown is [Figure 2](#), is generally preferred for low-ohms measurements. The 4-wire method cancels the effects of channel and test lead resistance.

These measurements can be made using the Model 2750 Digital Multimeter. With this configuration, the test current (I_{TEST}) is forced through the test resistance (R_{DUT}) through one set of test leads (R_{LEAD2} and R_{LEAD3}), while the voltage (V_M) across the Device Under Test (DUT) is measured through a second set of leads (R_{LEAD1} and R_{LEAD4}) called the sense leads.

With this configuration, the resistance of the DUT is calculated as follows:

$$R_{DUT} = V_M / I_{TEST}$$

where: I_{TEST} is the sourced test current and V_M is the measured voltage.

As shown in [Figure 2](#), the measured voltage (V_M) is the difference between V_{SHI} and V_{SLO} . The equations at the bottom of [Figure 2](#) show how test lead resistance and channel resistance is cancelled out of the measurement process.

Maximum test lead resistance (Model 2750)

[Table 1](#) lists the maximum test lead resistance (R_{LEAD}), plus the resistance of the DUT (R_{DUT}). Note that a larger test lead resistance can be tolerated with a smaller R_{DUT} , as shown in the following example:

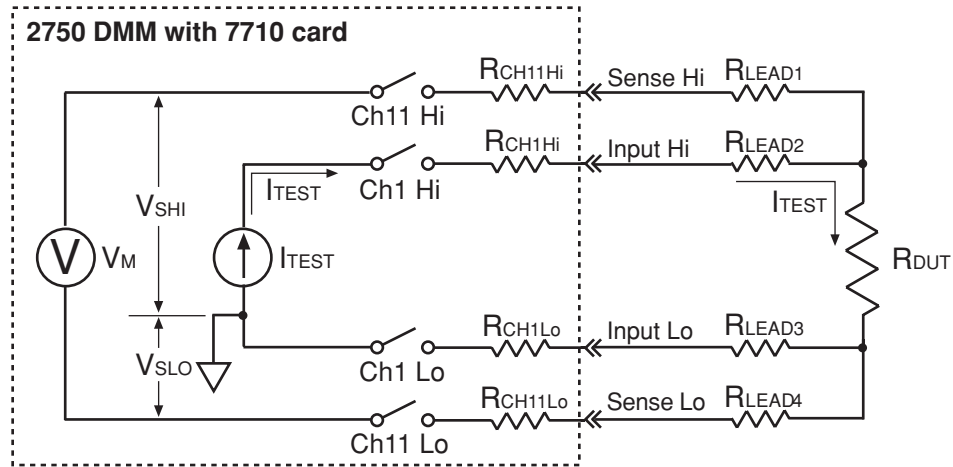
Example:

If R_{DUT} is 3 Ω on the 10 Ω range using the $\Omega 4$ (4-wire) function, then the maximum test lead resistance (R_{LEAD}) can be 4 Ω .

Table 1
Maximum test lead resistance (Model 2750)

Range	Ω		Ω 4		Ω 4 Dry Circuit	
	R _{LEAD}	R _{DUT}	R _{LEAD}	R _{DUT}	R _{LEAD}	R _{DUT}
1 Ω	NA	NA	0 Ω	1.2 Ω	Overflow	Overflow
10 Ω	0 Ω	2 Ω	0 Ω	7 Ω	3 Ω	12 Ω

Figure 2
Low-ohms measurements using 4-wire method



Assumptions: Virtually no current flows in the high-impedance sense circuit due to the high impedance of the voltmeter (V_M). Therefore, the voltage drops across Channel 11 and test leads 1 and 4 are negligible and can be ignored.

The voltage drops across Channel 1 Hi (R_{CH1Hi}) and test lead 2 (R_{LEAD2}) are not measured by the voltmeter (V_M).

$$R_{DUT} = \frac{V_M}{I_{TEST}} \quad \text{where: } V_M \text{ is the voltage measured by the 2750.}$$

I_{TEST} is constant current sourced by the 2750 to the DUT.

$$V_M = V_{SHI} - V_{SLO}$$

$$V_{SHI} = I_{TEST} \times (R_{DUT} + R_{LEAD3} + R_{CH1Lo})$$

$$V_{SLO} = I_{TEST} \times (R_{LEAD3} + R_{CH1Lo})$$

$$V_{SHI} - V_{SLO} = I_{TEST} \times [(R_{DUT} + R_{LEAD3} + R_{CH1Lo}) - (R_{LEAD3} + R_{CH1Lo})]$$

$$= I_{TEST} \times R_{DUT}$$

$$= V_M$$

Voltage measurements

As previously explained, path resistance can adversely affect “Low-ohms measurements” (see page 10). Series path resistance can also cause loading problems for DC voltage measurements on the 100V, 10V, and 10mV ranges when the 10M Ω input divider is enabled.

High signal path resistance can also adversely affect AC voltage measurements on the 100V range above 1kHz.

Insertion loss

Insertion loss is AC signal power lost between the input and the output. In general, as frequency increases, insertion loss increases.

For the 7710 card, insertion loss is specified for a 50Ω AC signal source routed through the module to a 50Ω load. Signal power loss occurs as the signal is routed through the signal paths of the module to the load.

Insertion loss is expressed as dB magnitudes at specified frequencies. The specifications for insertion loss are provided in the “Specifications” at the end of this User’s Guide. (See INSERTION LOSS in the “Specifications”.)

As an example, assume the following specifications for insertion loss:

<1dB @ 500kHz	1dB insertion loss is approximately 20% loss of signal power.
<3dB @ 2MHz	3dB insertion loss is approximately 50% loss of signal power.

As signal frequency increases, power loss increases.

NOTE The insertion loss values used in the above example may not be the actual insertion loss specifications of the Model 7710. The actual insertion loss specifications are provided in the “Specifications” at the end of this User’s Guide.

Crosstalk

An AC signal can be induced into adjacent channel paths on the 7710 card. In general, crosstalk increases as frequency increases.

For the 7710 card, crosstalk is specified for an AC signal routed through the module to a 50Ω load. Crosstalk is expressed as a dB magnitude at a specified frequency. The specification for crosstalk is provided in the “Specifications” at the end of this User’s Guide. (See CROSSTALK in the “Specifications”.)

As an example, assume the following specification for crosstalk:

<-40dB @ 500kHz	-40dB indicates that crosstalk into adjacent channels is 0.01% of the AC signal.
---------------------------	--

As signal frequency increases, crosstalk increases.

NOTE The crosstalk values used in the above example may not be the actual crosstalk specification of the Model 7710. The actual crosstalk specification is provided in the “Specifications” at the end of this User’s Guide.

Additional errors for 27xx switch systems

Additional 27xx measurement errors and typical system scanning speeds are provided after the first page of the “Specifications” on [page 21](#). These measurement errors are to be added on to the specifications of the Model 27xx mainframe being used in the switch system.

- Notes 1, 2 and 3 (and tables) for “DC CHARACTERISTICS” pertain to additional errors for high-ohms resistance measurements, voltage measurements, and temperature measurements.
- The two tables for “SYSTEM SPEEDS” provide speed data for scanning. For the various scan functions, the tables list the fundamental reading rate setting (in PLCs) and typical speed (in readings per second) into and out of memory.

Heat sink temperature measurements

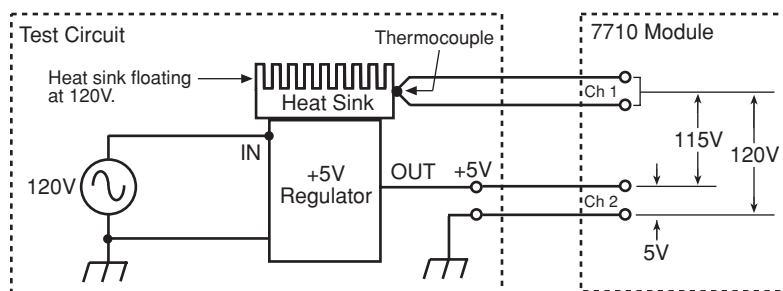
Measuring the temperature of a heat sink is a typical test for a system that has temperature measurement capability. However, the 7710 card cannot be used if the heat sink is being floated at a dangerous voltage level (>60V). An example of such a test is shown in Figure 3.

In Figure 3, the heat sink is floating at 120V, which is the line voltage being input to a +5V regulator. The intention is to use channel 1 to measure the temperature of the heat sink, and use channel 2 to measure the +5V output of the regulator. For optimum heat transfer, the thermocouple (TC) is placed in direct contact with the heat sink. This inadvertently connects the floating 120V potential to the 7710 card. The result is 115V between channel 1 and channel 2 HI, and 120V between channel 1 and chassis. These levels exceed the 60V limit of the card creating a shock hazard and possibly causing damage to the card.

WARNING The test in Figure 3 demonstrates how a dangerous voltage can unintentionally be applied to the 7710 card. Keep in mind that in any test where floating voltages >60V are present, you must be careful not to apply the floating voltage to the card.

Figure 3
Example of an unsafe measurement practice

WARNING DO NOT use the 7710 card to perform this type of test. It exceeds the 60V limit creating a shock hazard and could cause damage to the card. Excessive voltages:
The voltage differential between Ch 1 and Ch 2 HI is 115V.
The voltage differential between Ch 1 and Ch 2 LO (chassis) is 120V.



Ch 1 configured to measure TC temperature.
Ch 2 configured to measure 5V regulator output.

Card handling precautions

The solid state relays used on the 7710 card are static sensitive devices. Therefore, they can be damaged by electrostatic discharge (ESD).

CAUTION To prevent damage from ESD, only handle the module by the card edges. DO NOT touch the backplane connector terminals. When working with the quick-disconnect terminal blocks, DO NOT touch any circuit board traces or other components. If working in a high-static environment, use a grounded wrist strap when wiring the module.

Touching a circuit board trace may also contaminate it with body oils that may degrade the isolation resistance between circuit paths, adversely affecting measurements. It is good practice to handle a circuit board only by its edges.

Card connections

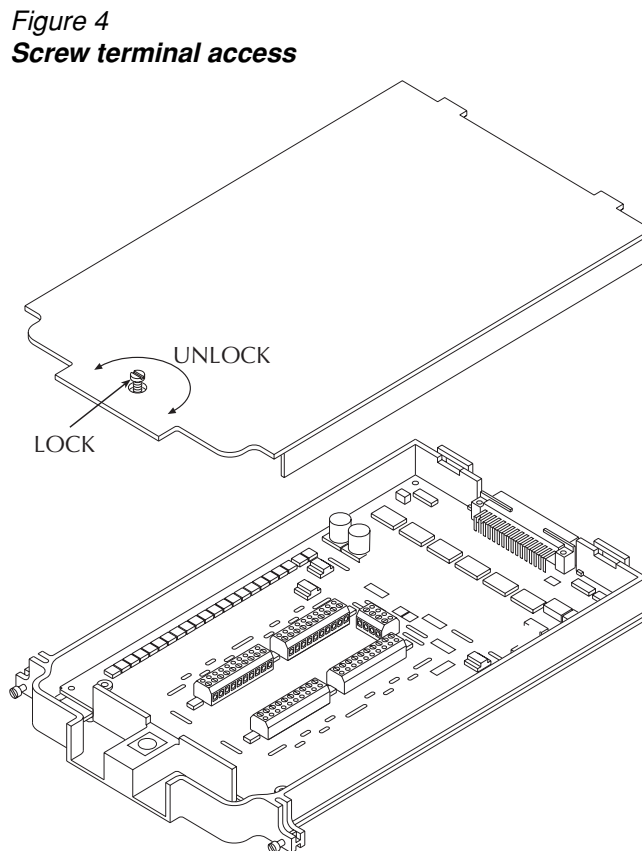
Screw terminals on the switching module are provided for connection to DUT and external circuitry. The Model 7710 uses quick-disconnect terminal blocks. A terminal block can be wired outside the module and then plugged back in. These terminal blocks are rated for 25 connect/disconnects.

Topics

WARNING The information in this section is intended for qualified service personnel. Do not attempt to perform this procedure unless qualified to do so.

Figure 4 shows how to access the screw terminals on the Model 7710. Channel designations for the screw terminals are contained in Figure 5.

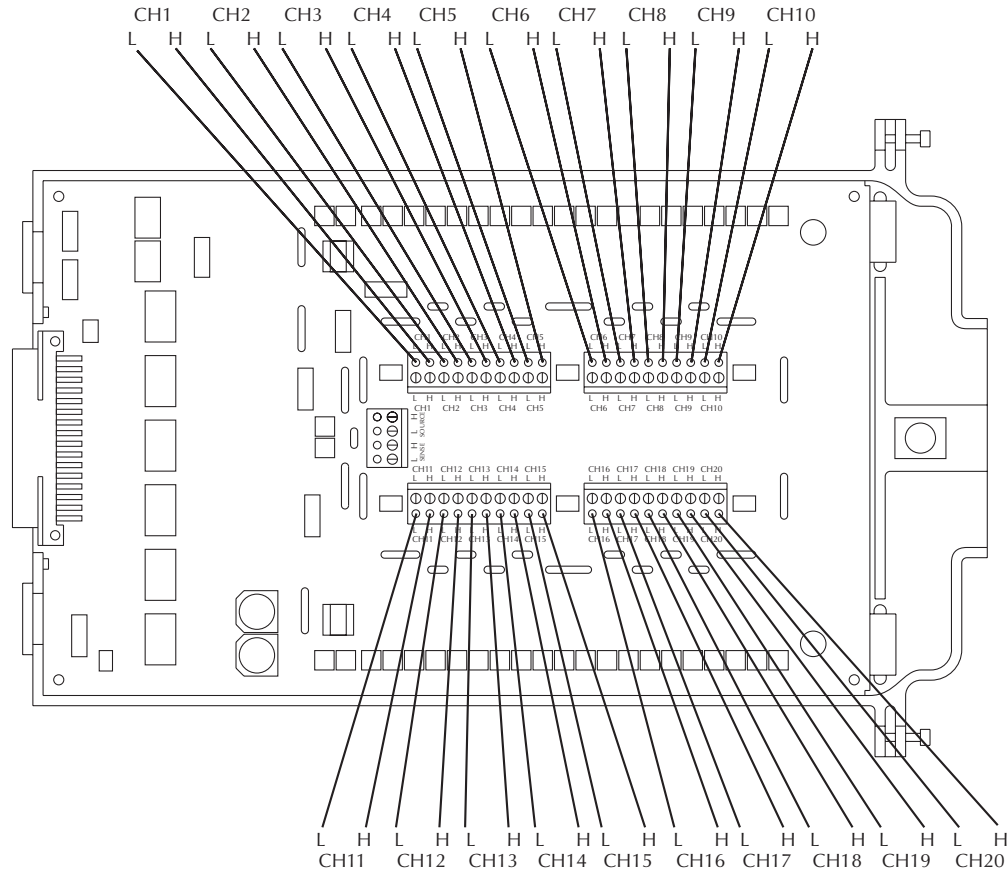
WARNING Do not exceed the maximum specifications for the Model 7710 card. Refer to the end of this User's Guide for specifications.



Topics

Topics

Figure 5
Model 7710 screw terminal channel designations



Topics

Topics

Wiring procedure

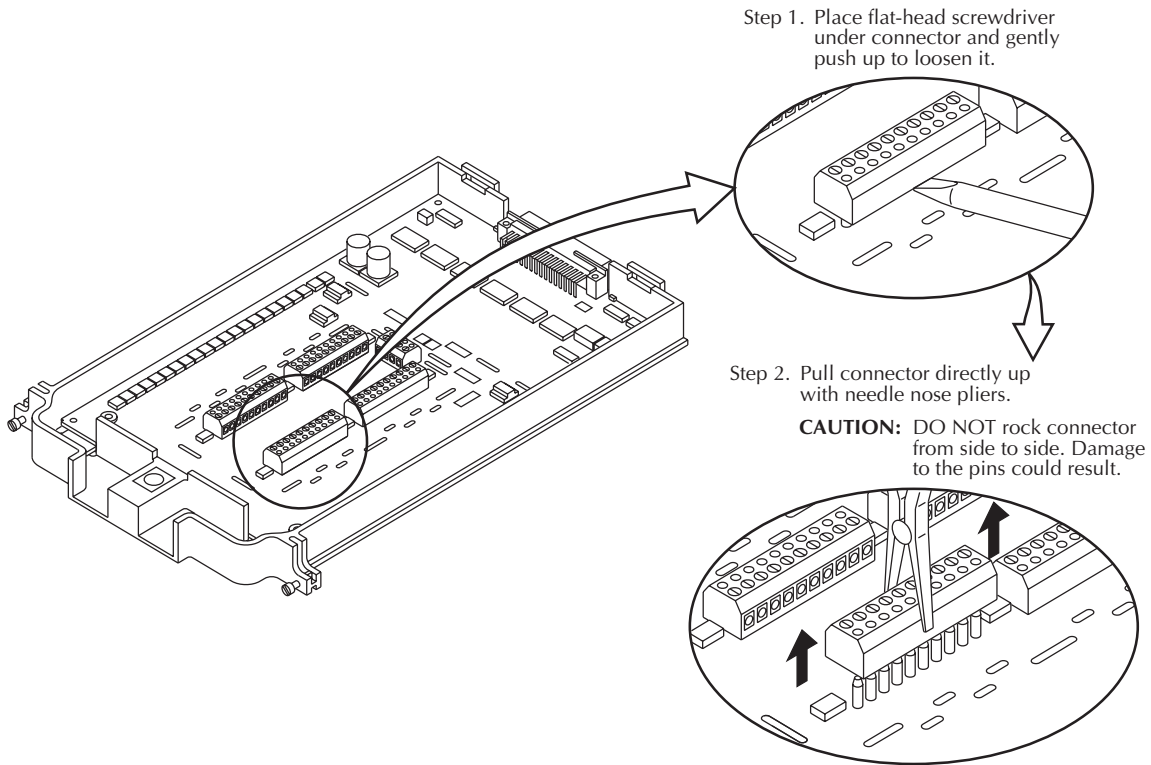
WARNING The information in this section is intended for qualified service personnel only. Do not attempt to perform this procedure unless qualified to do so.

Use the following procedure to wire the Model 7710 card. Make all connections using the correct wire size (up to 20 AWG). Also, make sure to add supplementary insulation around the harness for voltages above 42V peak (see [Figure 7](#)).

1. Make sure all power is discharged from the Model 7710 card.
2. Remove the card's top cover to gain access to the screw terminals (see [Figure 4](#)).
3. If desired, pull the appropriate quick-disconnect terminal block off the card.
4. Using a small flat-blade screwdriver, loosen terminal screws and install wires as desired (refer to [Figure 6](#)). [Figure 7](#) shows connections to channels 1 and 2.

Topics

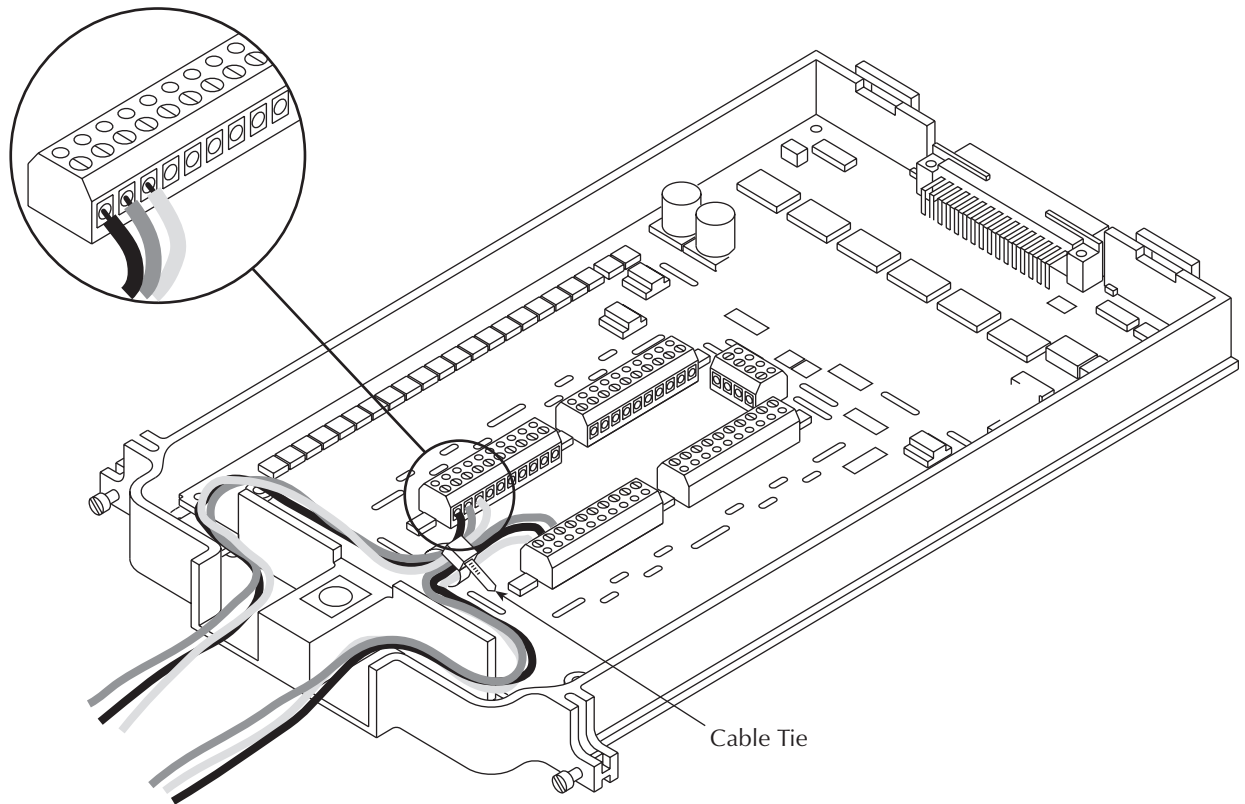
Figure 6
Proper procedure to remove terminal blocks



5. Plug the terminal block back into the card.
6. Route wire along wire-path and secure with cable ties as shown.
7. Fill in a copy of the connection log (Table 2 on page 18) and affix it to the module cover.
8. Close and lock cover.

NOTE For maximum system performance, all measurement cables should be less than 3 meters.

Figure 7
Wire dressing



Typical connections

The following examples show typical wiring connections for the following types of measurements:

- Thermocouple connections, see [Figure 8](#)
- Ω 2-wire and thermistor connections, see [Figure 9](#)
- Ω 4-wire and RTD connections, see [Figure 10](#)
- Voltage connections (DC or AC), see [Figure 11](#)

Figure 8
Thermocouple connections

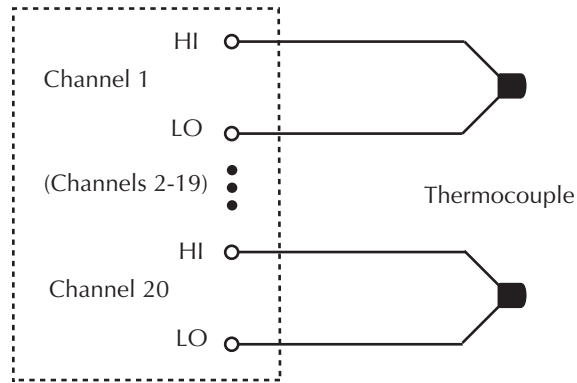
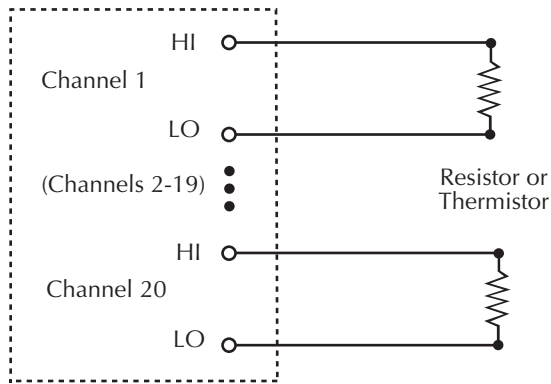


Figure 9
Ω 2-wire and thermistor connections



Topics

Topics

Topics

Figure 10
Ω 4-wire and RTD connections

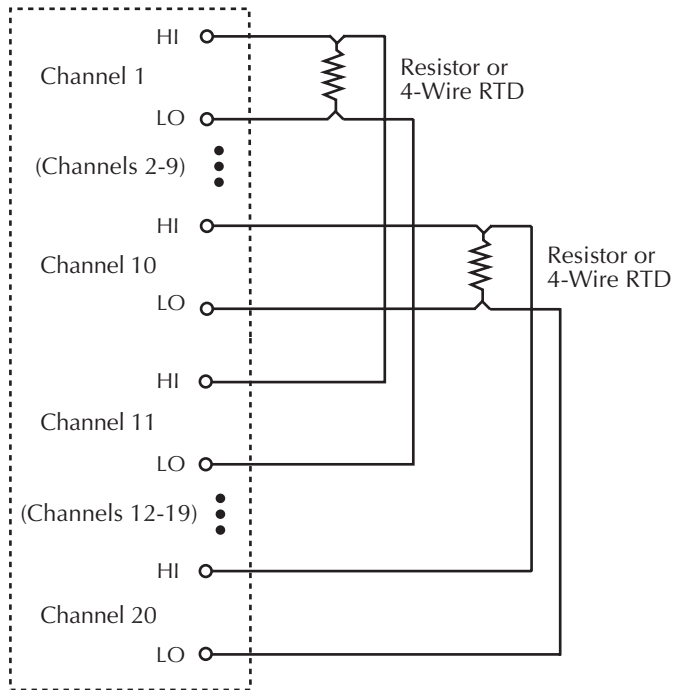
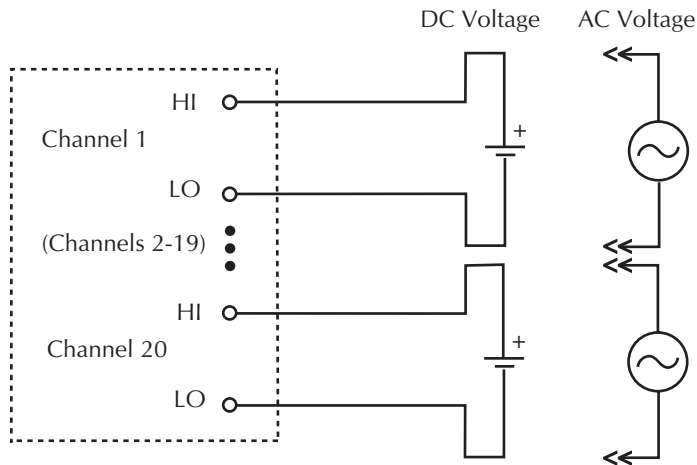


Figure 11
Voltage connections (DC or AC)



Connection log

Make a copy of [Table 2](#) and the **WARNING** and affix them to the cover of the Model 7710. Use this to record connection information and channel descriptions as needed.

WARNING The system’s maximum voltage, including other switch modules and front panel terminals, is limited to 60V peak-to-peak AC or DC between any terminal and chassis or any two terminals when the 7710 is installed.

Table 2
Connection log Model 7710

Channel		Color	Description
Card Source	H		
	L		
Card Sense	H		
	L		
CH1	H		
	L		
CH2	H		
	L		
CH3	H		
	L		
CH4	H		
	L		
CH5	H		
	L		
CH6	H		
	L		
CH7	H		
	L		
CH8	H		
	L		
CH9	H		
	L		
CH10	H		
	L		
CH11	H		
	L		
CH12	H		
	L		
CH13	H		
	L		
CH14	H		
	L		
CH15	H		
	L		
CH16	H		
	L		
CH17	H		
	L		
CH18	H		
	L		
CH19	H		
	L		
CH20	H		
	L		

Topics

Topics

Topics

Calibration

The following procedures calibrate the temperature sensors on the Model 7710 plug-in cards.

WARNING The information in this section is intended only for qualified service personnel. Do not attempt these procedures unless you are qualified to do so.

Recommended test equipment

In order to calibrate the Model 7710, you will need equipment summarized in [Table 3](#).

Table 3

Recommended equipment for Model 7710 calibration

Digital Thermometer: 18 to 23°C, ±0.1°C
Keithley 7797 Calibration/Extender Board

Extender board connections

The Model 7710 being calibrated should be connected to the 7797 Calibration/Extender Board, and the extender board should then be installed in scanner Slot #1. Note that the module being calibrated will be external to the Model 27xx to avoid card heating during calibration.

Model 7710 calibration

NOTE Before calibrating the Model 7710, make sure that power has been removed from the card for at least two hours to allow card circuitry to cool down. After turning on the power during the calibration procedure, complete the procedure as quickly as possible to minimize card heating that could affect calibration accuracy. Allow the Model 27xx to warm up for at least two hours.

Front panel Model 7710 calibration

1. Connect the Model 7710 to the Model 7797 Calibration/Extender Board (see “[Extender board connections](#)” above).
2. With the power off, install the Model 7710/7797 combination in Slot 1 and select the rear inputs with the INPUTS switch. Allow three minutes for thermal equilibrium.
3. Accurately measure and record the cold temperature of the Model 7710 card surface at the center of the card with a digital thermometer.
4. Press in and hold the Model 27xx OPEN key while turning on the power.
5. Press SHIFT then TEST, and then display TEST:CALIB with the up or down range key. Press ENTER, select RUN, and then enter the appropriate calibration code (default: 0027xx).
6. With NEW CODE? displayed, use the up or down range key to display N, and then press ENTER.
7. Using the up or down range key, select CARD at the CAL:RUN prompt, and then press ENTER.
8. Set the display value to the cold calibration temperature (°C) you measured in Step 3, then press ENTER to complete Model 7710 calibration.

Remote Model 7710 calibration

1. Connect the Model 7710 to the 7797 Calibration/Extender Board (see “[Extender board connections](#)”).
2. With the power off, install the Model 7710/7797 combination in Slot 1, and select the rear inputs with the INPUTS switch. Allow three minutes for thermal equilibrium.
3. Accurately measure and record the cold temperature of the Model 7710 card surface at the center of the card.
4. Press in and hold the Model 27xx OPEN key while turning on the power.
5. Enable calibration by sending the :CODE command. For example, the default command is:
`CAL:PROT:CODE 'KI0027xx'`
6. Initiate calibration by sending the following command:
`CAL:PROT:CARD1:INIT`
7. Calibrate the Model 7710 with the following command:
`CAL:PROT:CARD1:STEP0 <temp>`
Here <temp> is the cold calibration temperature (°C) measured in Step 3.
8. Send the following commands to save calibration and lock out calibration:
`CAL:PROT:CARD1:SAVE`
`CAL:PROT:CARD1:LOCK`

7710 20-Channel High-Speed/ Long-Life Differential Multiplexer w/ Automatic CJC Specifications

GENERAL

20 CHANNELS: 20 channels of 2-pole relay input. All channels configurable to 4-pole.

RELAY TYPE: Solid State Opto-Coupled FET

ACTUATION TIME: <0.5mS (100mA load)

FIRMWARE: Specified for Model 2700 Rev. B05, Model 2750 Rev. A04, and Model 2701 Rev. A01.

CAPABILITIES

CHANNELS 1-20: Multiplex one of 20 2-pole or one of 10 4-pole signals into DMM.

INPUTS

MAXIMUM SIGNAL LEVEL: 60V DC or 42V rms between channel (1-20) HI and channel LO or between any channel HI or LO to any other channel HI or LO, 100mA switched, 6W, 4.2VA maximum.

COMMON MODE VOLTAGE: 300V DC or 300V rms (425V peak) for AC waveforms between any terminal and chassis.

SAFETY: Conforms to European Union Directive 73/23/EEC EN61010-1, CAT I.

EMC: Conforms with European Union Directive 89/336/EEC EN61326-1.

CONTACT LIFE: >10¹⁰ operations at cold switching or max signal level (guaranteed by design).

CONTACT RESISTANCE: <10Ω per channel or <5Ω per conductor. Refer to the Model 7710 User's Guide for measurement considerations when used in a Model 2750 on the 1Ω or 10Ω ranges.

CONTACT POTENTIAL: <3μV per pair.

OFFSET CURRENT: <1nA @ 23°C (±5°C) for 0V, <5nA @ 23°C (±5°C) for 60V, additional 0.13nA per 1°C above 28°C.

CONNECTOR TYPE: 3.5mm Removable Screw Terminals, #20 AWG wire size.

ISOLATION BETWEEN ANY TWO TERMINALS: >10¹⁰Ω @ 23°C, >8•10⁹Ω @ 50°C, <100pF.

ISOLATION BETWEEN ANY TERMINAL AND EARTH: >10¹⁰Ω, <100pF.

CROSSTALK (CH-CH, 500kHz, 50Ω Load): <-40dB.

INSERTION LOSS (50Ω Source, 50Ω Load): <1dB below 500kHz, <3dB below 2MHz.

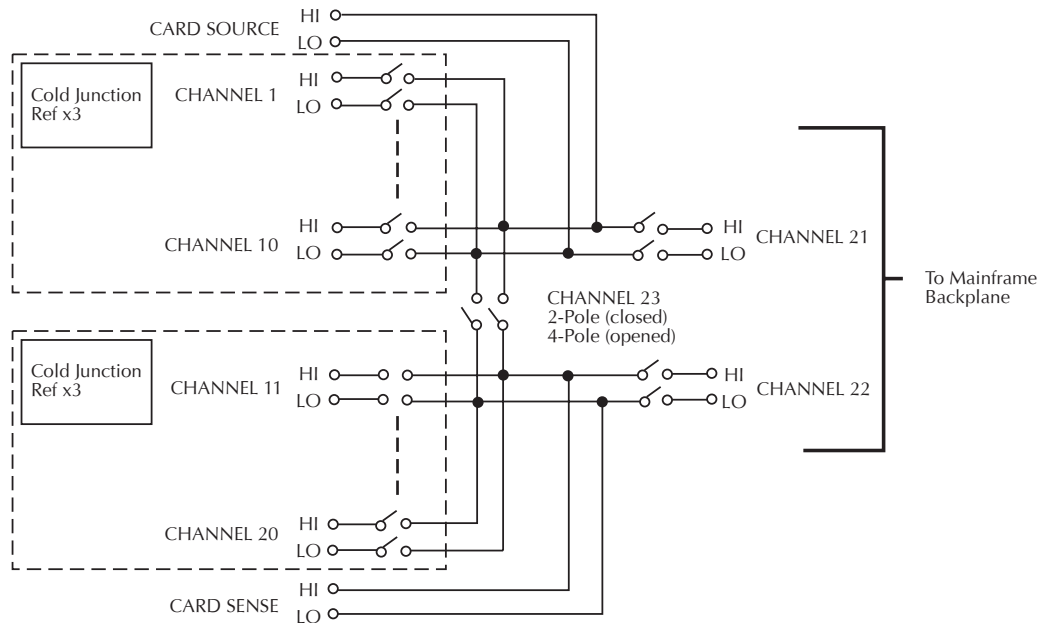
ENVIRONMENTAL

OPERATING ENVIRONMENT: Specified for 0°C to 50°C.
Specified for 80% R.H. at 35°C.

STORAGE ENVIRONMENT: -25°C to 65°C.

WEIGHT: 0.45kg (1 lb).

ALTITUDE: <2km.



Specifications are subject to change without notice.

All Keithley trademarks and trade names are the property of Keithley Instruments, Inc. All other trademarks and trade names are the property of their respective companies.

KEITHLEY

Keithley Instruments, Inc.

28775 Aurora Road • Cleveland, Ohio 44139 • 440-248-0400 • Fax: 440-248-6168
1-888-KEITHLEY (534-8453) • www.keithley.com

Sales Offices:	BELGIUM:	Bergensesteenweg 709 • B-1600 Sint-Pieters-Leeuw • 02-363 00 40 • Fax: 02/363 00 64
	CHINA:	Yuan Chen Xin Building, Room 705 • 12 Yumin Road, Dewai, Madian • Beijing 100029 • 8610-8225-1886 • Fax: 8610-8225-1892
	FINLAND:	Tietäjäsentie 2 • 02130 Espoo • Phone: 09-54 75 08 10 • Fax: 09-25 10 51 00
	FRANCE:	3, allée des Garays • 91127 Palaiseau Cédex • 01-64 53 20 20 • Fax: 01-60 11 77 26
	GERMANY:	Landsberger Strasse 65 • 82110 Germering • 089/84 93 07-40 • Fax: 089/84 93 07-34
	GREAT BRITAIN:	Unit 2 Commerce Park, Brunel Road • Theale • Berkshire RG7 4AB • 0118 929 7500 • Fax: 0118 929 7519
	INDIA:	1/5 Eagles Street • Langford Town • Bangalore 560 025, INDIA • 080 212 8027 • Fax : 080 212 8005
	ITALY:	Viale San Gimignano, 38 • 20146 Milano • 02-48 39 16 01 • Fax: 02-48 30 22 74
	JAPAN:	New Pier Takeshiba North Tower 13F • 11-1, Kaigan 1-chome • Minato-ku, Tokyo 105-0022 • 81-3-5733-7555 • Fax: 81-3-5733-7556
	KOREA:	2FL., URI Building • 2-14 Yangjae-Dong • Seocho-Gu, Seoul 137-888 • 82-2-574-7778 • Fax: 82-2-574-7838
	NETHERLANDS:	Postbus 559 • 4200 AN Gorinchem • 0183-635333 • Fax: 0183-630821
	SWEDEN:	c/o Regus Business Centre • Frosundaviks Allé 15, 4tr • 169 70 Solna • 08-509 04 679 • Fax: 08-655 26 10
	TAIWAN:	13F-3. No. 6, Lane 99 Pu-Ding Road • Hsinchu, Taiwan, R.O.C. • 886-3-572-9077 • Fax: 886-3-572-9031